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AQUATIC PLANT WASTEWATER TREATMENT SYSTEMS

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AQUATIC PLANT WASTEWATER TREATMENT SYSTEMS

INTRODUCTION

Having been used, abused and largely taken for granted for decades, America's clean water supplies are slowing to a trickle.

No region of the country is immune to water-related problems. Wet states as well as dry have water problems. The Gulf Coast region enjoys an abundant rainfall, but most residents get their water from underground aquifers. In some areas, the underground aquifers are so close to the surface that they are being contaminated by polluted surface waters. Over the years, salt water, septic tank leakage, and agricultural and industrial chemicals have been slowly polluting many drinking water supplies. As the U. S. grows, demand for the limited supply of clean, fresh water is also increasing.

Because approximately 95 percent of the water on Earth is salt water in oceans, and a large percentage of the fresh water is frozen at the North and South Poles, man has a very limited quantity of fresh water for his many needs. This limited supply of fresh water is creating a water problem that, by comparison, will make the energy crisis a minor inconvenience.

The answer to this emerging water crisis is the development of an economical means of treating and reusing domestic, agriculture, aquaculture, and industrial wastewater (2,5,6).

The available mechanical wastewater treatment plants are too complex, costly and energy intense for use in small towns and rural areas in the U. S. and throughout the developing countries of the world. Wastewater treatment systems that are simple and require little or no maintenance must be developed for these areas.

A very promising, simplified method of wastewater treatment using natural, biological processes has been developed by the National Aeronautics and Space Administration (NASA). This process, which uses aquatic plants and their associated microorganisms, has been developed at the John C. Stennis Space Center (SSC) in Mississippi over the past 16 years (4-18). Although NASA's primary goal for this technology is future space application, immediate, earthly applications are being pursued.

This paper discusses the practical application of this technology in solving some of the present wastewater treatment problems in small towns and rural areas in the U. S. and throughout the world.

SCIENTIFIC BASIS FOR USING AQUATIC PLANTS IN WASTEWATER TREATMENT

Biologically, the aquatic plant systems are far more diverse than present day mechanical treatment systems. Oxidation ditches and other types of extended aeration treatment systems use energy intensive mechanical aerators to supply large amounts of oxygen for growing aerobic microorganisms which treat the wastewater.

The scientific basis for waste treatment in a vascular aquatic plant system is the cooperative growth of both the plants and the microorganisms associated with the plants. A major part of the treatment process for degradation of organics is attributed to the microorganisms living on and around the plant root systems.

Once microorganisms are established on aquatic plant roots, in most cases they form a symbiotic relationship with the higher plants. This relationship normally produces a synergistic effect resulting in increased degradation rates and removal of organic chemicals from the wastewater surrounding the plant root systems. Products of the microbial degradation of the organics are absorbed and utilized as a food source by the plants along with N, P, K and other minerals. Microorganisms also use metabolites released through plant roots as a food source. By each using the others waste products, this allows a reaction to be sustained in favor of rapid removal of organics from wastewater. Electric charges associated with aquatic plant root hairs also react with opposite charges on colloidal particles such as suspended solids causing them to adhere to the plant roots where they are removed from the wastewater stream and slowly digested and assimilated by the plant and microorganisms. Aquatic plants have the ability to translocate O_2 from the upper leaf areas into the roots producing an aerobic zone around the roots which is desirable in domestic sewage treatment.

Although a great deal is known about the biological reactions which take place between environmental pollutants, plants and microorganisms, these reactions are complex and the biochemical processes are not fully understood.

SEPTIC TANK/ARTIFICIAL MARSH WASTEWATER TREATMENT SYSTEMS

A 12,000 gpd (45.4 m^3) septic tank/artificial marsh system is in operation at Pearlington, Mississippi, located on the Mississippi Gulf Coast. This system treats the wastewater from a mobile home park, Figure 1.

The small town of Vredenburg, Alabama, also has in operation a septic tank/artificial marsh system which treats 40,000 gpd (151.4 m^3) of domestic wastewater. This system uses a combination of open channel/plant filters combined with a rock/plant filter to treat the septic tank effluent as shown in Figure 2.

SEWAGE LAGOON/ARTIFICIAL MARSH WASTEWATER TREATMENT SYSTEMS

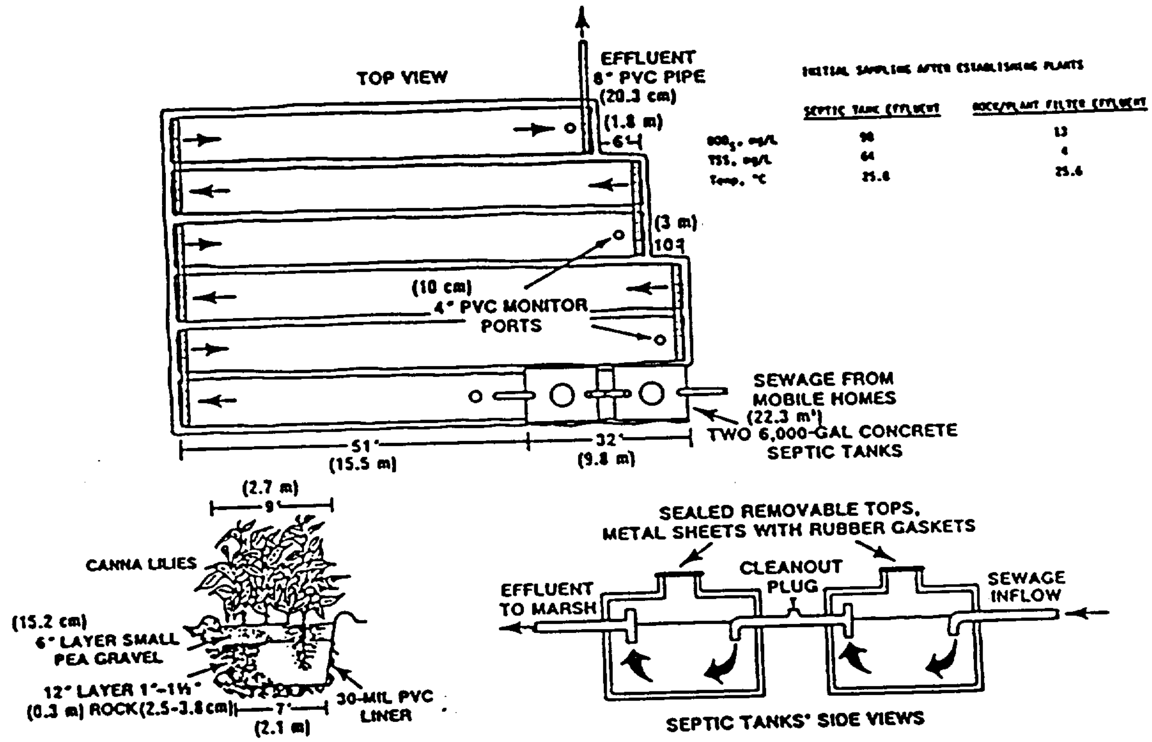
The sewage lagoon/artificial marsh wastewater treatment systems differ from septic tank/artificial marsh wastewater treatment systems in that lagoons are used rather than septic tanks for receiving raw sewage. Generally these systems are much larger than septic tank systems and the effluent is aerobic.

The largest lagoon/artificial marsh system under construction in the U.S., located at Denham Springs, Louisiana, Figure 3, is designed to treat 4,000,000 gpd (15,152 m^3). A similar system located in Haughton, Louisiana is designed to treat 350,000 gpd (1,326 m^3). It has been in operation for over a year in this north Louisiana town, Figure 4. To date, very good results have been achieved by this system as shown in Table 1. Another similar system located in the small northern Louisiana town of Benton has recently begun operation. This system has the same design capacity as the Haughton, Louisiana system. Carville, in central Louisiana, has an artificial marsh filter receiving effluent from an aerated multi-cell lagoon system, Figure 5. This system treats 150,000 gpd (568 m^3). Since operation began in mid-1987, it has produced an effluent discharge averaging 6.8 mg/L BOD_5 and 7.0 mg/L TSS, as shown in Table 2.

The Louisiana artificial marsh filters discussed in this paper all contain rocks and are operated with hydraulic retention times ranging from 24 to 48 hours. In Mississippi, there are four open channel artificial marsh systems which have no rocks. One marsh filter is located at Collins, Mississippi, Figure 6, and three at NASA's John C. Stennis Space Center

Figure 1

SEPTIC TANK ROCK/PLANT WASTEWATER TREATMENT SYSTEM FOR SUNRISE HAVEN MOBILE HOME PARK, PEARLINGTON, MISSISSIPPI



INITIAL SAMPLING AFTER ESTABLISHING PLANTS

	SEPTIC TANK EFFLUENT	ROCK/PLANT FILTER EFFLUENT
BOD_5, mg/L	[illegible]	13
TSS, mg/L	64	4
Temp, °C	25.8	25.6

Figure 2

SEPTIC TANK/ARTIFICIAL MARSH WASTEWATER TREATMENT SYSTEM FOR THE TOWN OF VREDENBURGH, ALABAMA

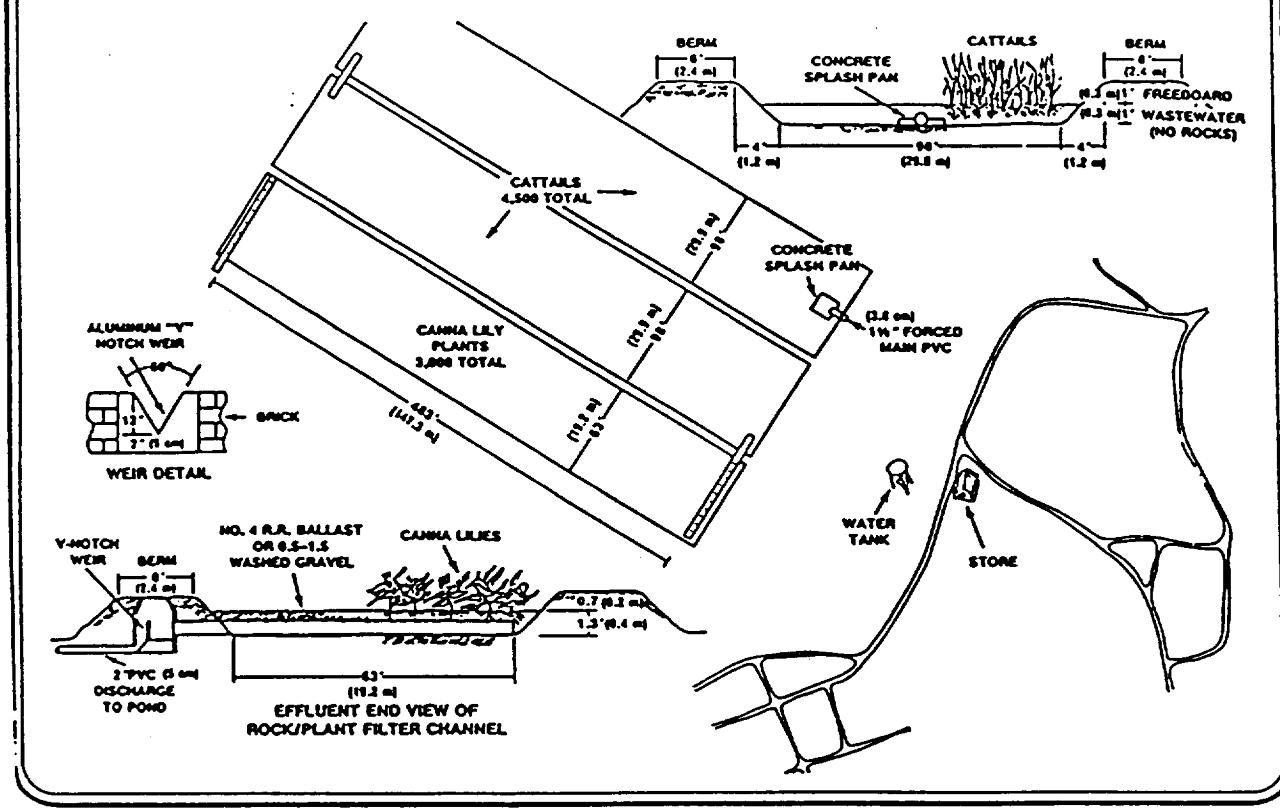


Figure 3

ARTIFICIAL MARSH WASTEWATER TREATMENT SYSTEM FOR CITY OF DENHAM SPRINGS, LOUISIANA

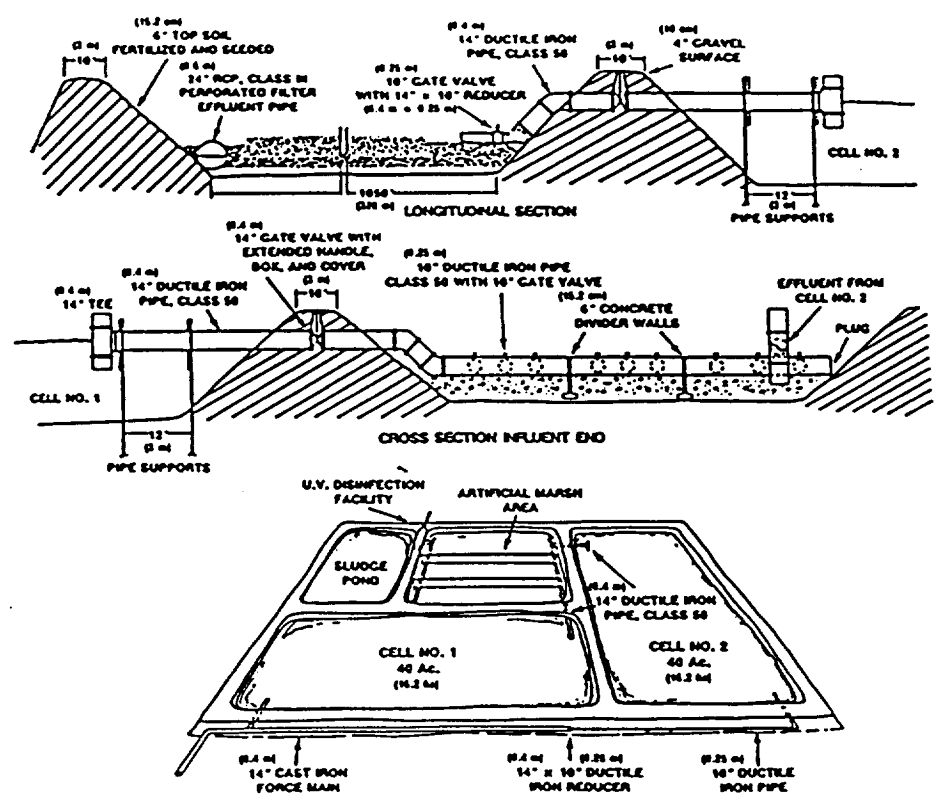


Figure 4

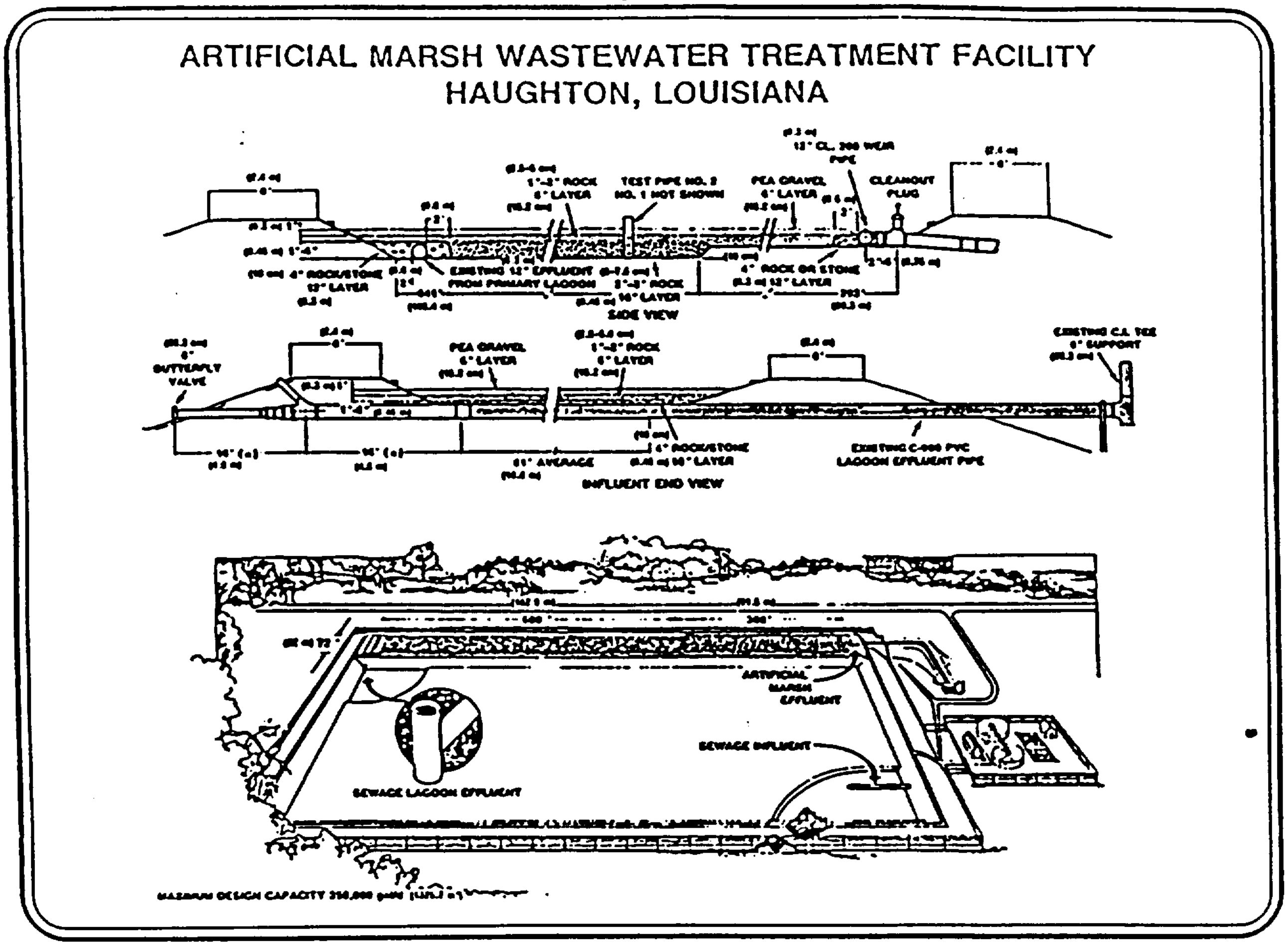


Table 1

HAUGHTON, LOUISIANA

ROCK/PLANT MARSH FILTER, mg/L

	Lagoon Effluent Marsh Filter Influent		Marsh Filter Effluent	
Date	BOD_5	TSS	BOD_5	TSS
5/87	58.0	122	5.7	0.0
6/87	31.2	76	12.3	13.0
7/87	46.0	94	10.4	6.0
8/87	45.4	185	10.4	10.2
9/87	---	---	6.4	9.5
10/87	---	---	11.4	7.5
11/87	---	---	9.1	6.0
12/87	---	---	8.2	5.0
1/88	---	---	14.0	13.0
2/88	---	---	16.2	12.5
3/88	---	---	16.2	19.0
4/88	---	---	5.8	2.5

Figure 5

ARTIFICIAL MARSH WASTEWATER TREATMENT FACILITY
CARVILLE, LOUISIANA

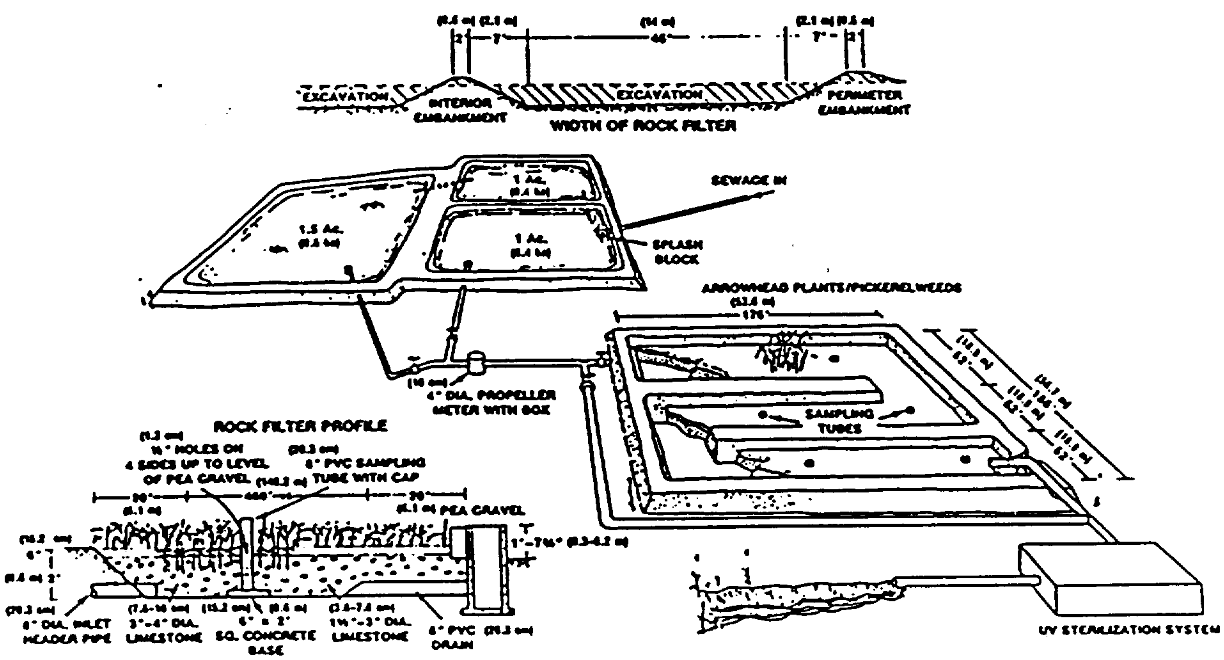


Table 2

CARVILLE, LOUISIANA

GILLIS W. LONG HANSEN'S DISEASE CENTER

ROCK/PLANT MARSH FILTER, mg/L

	MARSH FILTER EFFLUENT		
DATE	BOD_5	TSS	NH_3-N
7/87	3.5	3.5	0.40
8/87	7.5	2.5	0.75
9/87	7.0	----	1.60
10/87	7.5	7.0	0.55
11/87	3.5	6.0	0.45
12/87	3.0	1.0	0.70
1/88	14.5	18.5	0.38
2/88	4.5	9.0	0.07
3/88	10.0	8.5	1.15

Figure 6

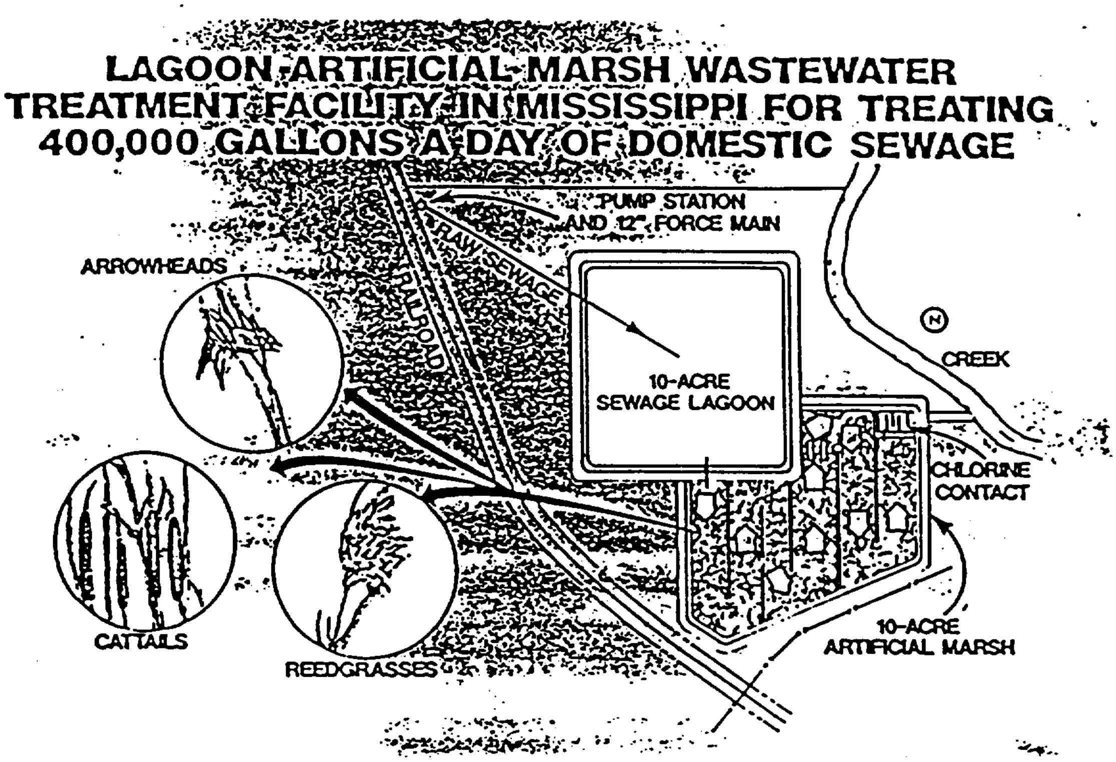


Table 3

COLLINS, MISSISSIPPI

OPEN-CHANNEL BULRUSH/DUCKWEED MARSH

FILTER, mg/L

	MARSH FILTER EFFLUENT		
DATE	BOD_5	TSS	TEMP °C
10/26/87	8.4	---	15.0
11/25/87	6.5	12.0	---
12/16/87	7.7	4.0	8.0
1/15/88	1.1	1.0	6.0
2/24/88	4.0	16.0	9.5
3/24/88	9.8	8.0	8.0

(SSC) in south Mississippi. Data from six months of monitoring of the Collins system is shown in Table 3. Water depths in these marsh filters range from are 1 to 2 ft (.3 to .6 m), with hydraulic retention times ranging from 5 to 10 days. Three of the open channel marsh filters are planted with southern bulrush (*Scirpus californicus*) and duckweed (*Lemna*, *Spirodela* and *Wolffia* spp.). The fourth open channel marsh system has been in operation at SSC over 10 years. It receives effluent from a small mechanical package plant. The filter measures 14.1 ft (4.3 m) W x 115 ft (35 m)L x 1.2 ft (.38 m) D and contains a combination of pennywort (*Hydrocotyle umbellata*) and duckweed (*Lemna*, *Spirodela*, and *Wolffia* spp.). The yearly average effluent BOD_5 is reduced from 35.5 mg/L to 3.0 mg/L with a hydraulic retention time of 7 to 8 days.

TEMPERATURE EFFECTS ON THE SEPTIC TANK/ARTIFICIAL MARSH TREATMENT SYSTEM

Studies conducted in the state of Washington, Canada and Alaska have indicated that septic tank systems perform satisfactorily during the winter months in these cold climates. Experiments at Fairbanks and Anchorage, Alaska demonstrated that the large amount of heat provided to the septic tank by wastewater from the residence appears to be a significant factor in maintaining the disposal system at an operable temperature (3). Cold tolerant plants such as bulrushes and cattails must be used when installing septic tank/artificial marsh wastewater treatment systems in cold climates. Studies in Anchorage also demonstrated the better insulating properties of concrete tanks over steel tanks. (1)

SUMMARY

1. Artificial marsh technology for upgrading domestic septic tank, primary settling tank, and various types of sewage lagoon effluent has been sufficiently developed to meet secondary and advanced secondary levels of wastewater treatment in tropical and semi-tropical zones.

2. Large septic tanks are being used in some small towns and communities in lieu of open sewage lagoons. This type of wastewater treatment system has many advantages over open lagoon systems. Tanks can be installed underground in many different locations throughout the collection area, taking advantage of the land elevations. All of the tanks can then be connected to drain pipes which take the effluent to one or more artificial marsh filters for treatment. The size of the marsh filter system will be dictated by the volume of septic tank effluent and the level of treatment desired. When these systems are properly installed, there will be no open air exposure to sewage before treatment has been accomplished. If, at any time after start-up of the system, odor is detected then some component of the system was improperly installed.

3. The use of rock/marsh filters and open channel/plant/marsh filters has been successful in a polishing mode to upgrade sewage lagoon effluent to secondary and advanced secondary treatment levels. When multi-cell lagoons are used or a combination of open channel and rock/marsh filters are used, tertiary treatment levels can be achieved.

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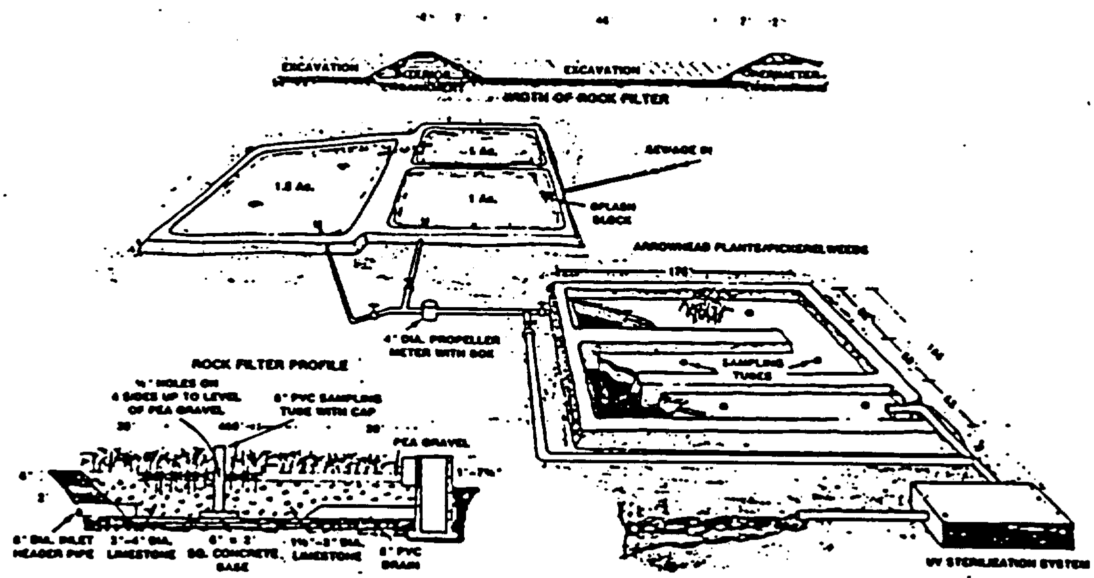

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2/88	4.5	9.0	0.07
3/88	10.0	8.5	1.15
4/88	10.0	11.0	----
5/88	5.0	3.0	2.00
6/88	8.5	7.0	1.00
7/88	7.5	12.0	0.98
8/88	4.5	1.0	1.20
9/88	6.0	3.0	1.10
10/88	6.4	0.2	1.30

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